4.4 Exchangers

All Heat Exchanger Data was reviewed and update for all the exchanger during this Shutdown. Any gasket changes and torque procedure revisions were documented in the 2 binders labeled D&R 1Q 2007 S/D Heat Exchanger Gasket Info and Updates.

4.4.1 E-1100 A-F

These exchangers were replaced with new bundles this shutdown. New fans and motors were ordered as well.

The structural steel was replaced for the A/B bundles because of the fire. These work orders should be with the CURE final report.

Ref Drop Folder in D&R library

4.4.2 E-1101 A-D

Parts that will be referenced:

- ***Channel*** – bolts to inlet piping and shell
- ***Shell*** – bolts to channel and shell pot
- ***Shell Pot*** – bolts to the shell and the tail pipe mating spool
- ***Bellows / Floating head*** – bolts to the bundle and tail pipe mating spool
- ***Tail Pipe Mating Spool*** – Bolts to the shell pot and bellows on one side (3 gaskets total) and the outlet piping on the other

These exchangers were found to have significant gasket surface corrosion on the internal components. In addition, a few gasket surfaces were damaged by the contractor during dismantling. The following work was completed:

E-1101A – Weld built and machined the tail pipe mating spool gasket surface (side with 3 gaskets), skim cut the other gasket surface on the tail pipe mating spool (outlet flange), skim cut the shell pot gasket surface (Shell Pot – Tail Pipe Mating Spool), skim cut the channel inlet flange, and weld built and machined the bellows outlet flange gasket surface (bellows – tail pipe mating spool).

E-1101B – Weld built and machined the tail pipe mating spool gasket surface (side with 3 gaskets), weld built and machined the shell pot gasket

surface (Shell Pot – Tail Pipe Mating Spool), skim cut the channel inlet flange, and skim cut the shell pot gasket surface (Shell Pot – Shell).

E-1101C – Weld built and machined the tail pipe mating spool gasket surface (side with 3 gaskets), weld built and machined the shell pot gasket surface (Shell Pot – Tail Pipe Mating Spool), and skim cut the channel inlet flange,

E-1101D – Weld built and machined the tail pipe mating spool gasket surface (side with 3 gaskets), weld built and machined the shell pot gasket surface (Shell Pot – Tail Pipe Mating Spool), skim cut the other shell pot gasket surface (Shell Pot – Shell), skim cut the channel inlet flange, skim cut the shell outlet flange, and replaced the bellows assembly (reused the floating head and outlet flange).

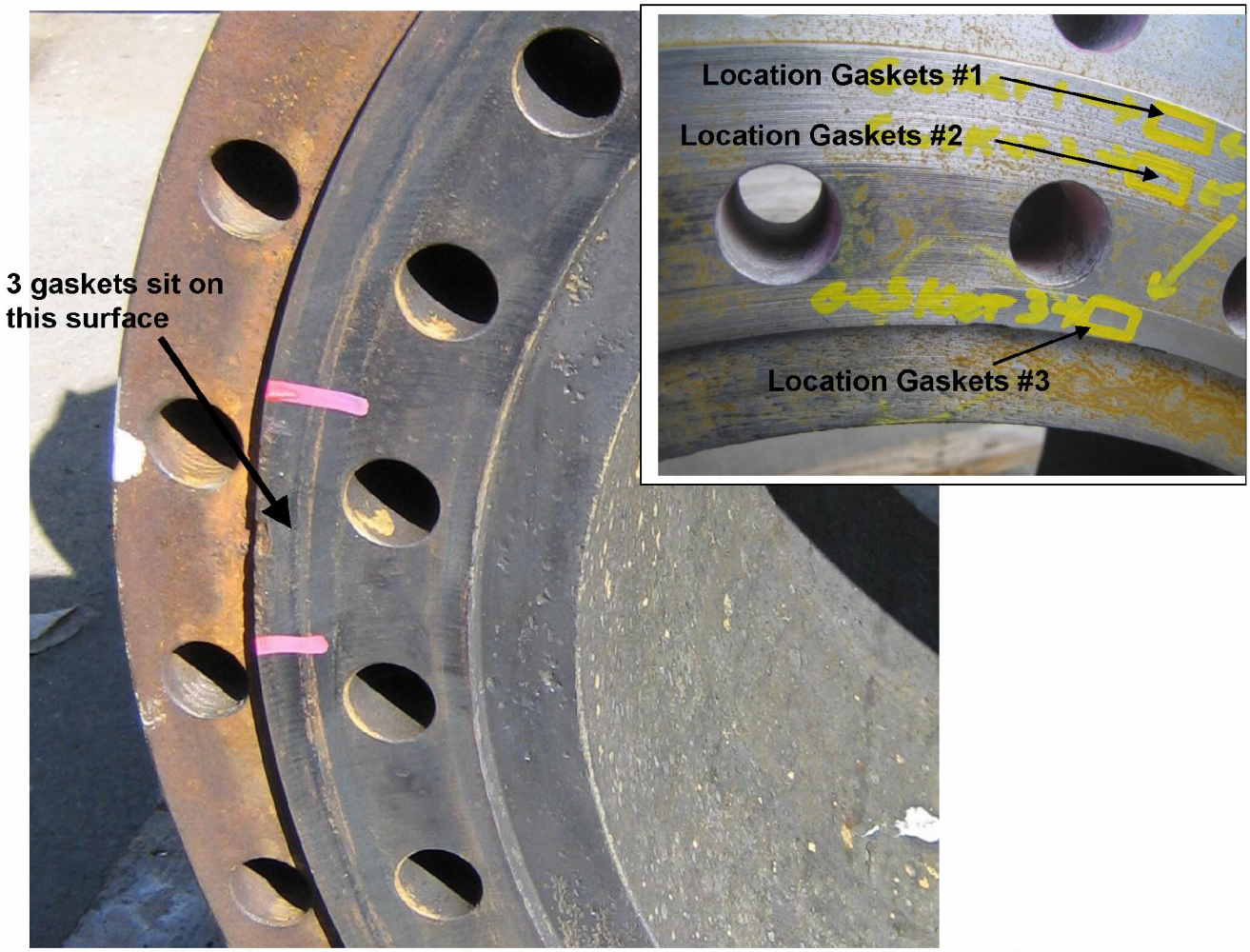

Figure 4.5.2.1. Example of gasket surface damage on E-1101B tail pipe mating spool.

The bellows in E-1101D was replaced due to severe corrosion, with pits greater that 0.40". The bellows was last replaced in 2002, so all of the corrosion occurred in the last 4-5 years. We found that the continuous drain on the shell pot was plugged, allowing water and other corrosives to sit in the shell on the outside of the bellows.

To replace the bellows, significant weld build was required on the outlet flange due to pitting. The excessive welding warped the holes in the outlet flange, causing us to have to bend the studs to attach the tail pipe mating spool. We did not have enough time to acquire a new forged outlet flange.

Figure 4.5.2.2. Bellows corrosion on E-1101 D.

All of the tail pipe mating spool gaskets were changed from clad to CamPro. Heat Exchanger Data Base was updated. The largest of the gaskets must be centered on the shell pot before the tail pipe mating spool is installed. If not centered properly, it can drastically reduce the effective sealing area on the gasket. On E-1101A (suffered a leak on-the-run), the gasket was not centered last time it was installed, allowing only 1/2 of the 3/8" wide gasket to be clamped. This may have contributed to the leak.

It was also noted that during the last turnaround the bundles had been installed 90 degrees off of where they should have been. We determined

that the sealing bars (or skid bars) should be 90/270 degrees off of the shell inlet and outlet nozzles.

All four shells were coated around the support rings due to CUI. The exchangers were not reinsulated.

Revisions made to Heat exchanger data base during S/D for E-1101 A-D
- Changed Stud length for expansion joint "I" and "O" from 4.5" to 5".
- Changed Stud length of FLHD to FLTS from 11.25" to 12.5"

A drop folder in the D&R library contains details on all of the repairs and on the orientation of the bundle.

Ref S/D EWO# BE402-E1 Rev. 0
Ref S/D EWO# BE402-E2 Rev. 0
Ref S/D EWO# BE402-E3 Rev. 1
Ref S/D EWO# BE402-E4 Rev. 1
Ref S/D EWO# BE402-E5 Rev. 0
Ref S/D EWO# BE402-E6 Rev. 0
Ref S/D EWO# BE402-E7 Rev. 0
Ref S/D EWO# BE402-E8 Rev. 0
Ref Drop Folder in D&R Library

RECOMMENDATION E-1101 A-D: Ensure that the shell pot drain lines are blown down every shutdown. When bundles are disassembled, ensure that the bundles are reinstalled in the correct orientation and that the gaskets are centered on the tail pipe mating spool.

RECOMMENDATION E-1101 A-D: Change the outside diameter of Expansion Joint Gasket O (tail pipe spool – shell pot) from 22 7/8" to 22 15/16". This change should help with the centering issue mentioned above. It may be prudent to order a spare gasket in the old size just in case the new gasket does not fit.

RECOMMENDATION E-1101D: Replace the forged flange on the floating head bellows outlet for E-1101D. The outlet flange is distorted from welding.

4.4.3 E-1102 A-C

These exchangers were opened, cleaned, and reinstalled. All bundles were in good shape.

There were repairs performed to the channel and channel cover for E-1102C. There was bypassing on the middle partition plate that caused

some erosion/corrosion. The channel cover and partition plate were weld built and machined back to original specifications.

Some damage was noted on the shell of E-1102 A and C from bundle removal. The skids of the bundle were drug along the shell causing severe burrs which were draw filed off.

Figure 4.5.3.1. Damage to the shell gasket surface on E-1102B.

Twelve tubes in E-1102A were plugged due to mechanical damage.

Ref S/D EWO# BE405-E1 Rev. 0

RECOMMENDATION: Ensure that contractors are aware of the damages that can occur from improper bundle removal.

4.4.4 E-1103

Bundle was removed, cleaned, and inspected. No problems were noted for the bundle, channel, shell, or channel cover.

4.4.5 E-1104

Bundle was removed, cleaned, and inspected. No problems were noted for the bundle, channel, shell, or channel cover.

4.4.6 E-1105 B

Bundle was removed, cleaned, and inspected. No problems were noted for the bundle, channel, shell, or channel cover.

4.4.7 E-1106

Bundle was removed, cleaned, and inspected. No problems were noted for the bundle, channel, shell, or channel cover.

4.4.8 E-1107 A/B

A and B bundles were removed, cleaned, inspected, and reinstalled. There were no repairs and no bundle problems were reported by inspections. There was some minor pitting noted by inspections on the channel cover gasket surface on E-1107 B. No repairs were done because the pitting was minor and did not compromise more than 50% of the gasket surface.

Figure 4.5.8.1. Pitting noted by inspections on E-1107B channel cover gasket surface.

A ¾" bleeder on the channel inlet was replaced in-kind on E-1107B because it was bent.

Figure 4.5.8.2. Bent ¾" bleeder valve on E-1107B channel.

Ref S/D EWO# BE412-E1 Rev. 0

4.4.9 E-1108 C

Bundle was removed, cleaned, and inspected. No problems were noted for the bundle, channel, shell, or channel cover.

4.4.10 E-1109

Bundle was removed, cleaned, and inspected. The first pass suffered badly from thinning tubes, pitting, and end impingement. The other passes did not have any significant metal loss. Given these facts, we decided to retube only the first pass. The work was complete by Benicia Fab.

A TAW was written to skim cut one of the channel nozzles gasket surfaces. This was denied because the blemishes in the gasket surface were not deep enough to warrant taking a skim cut.

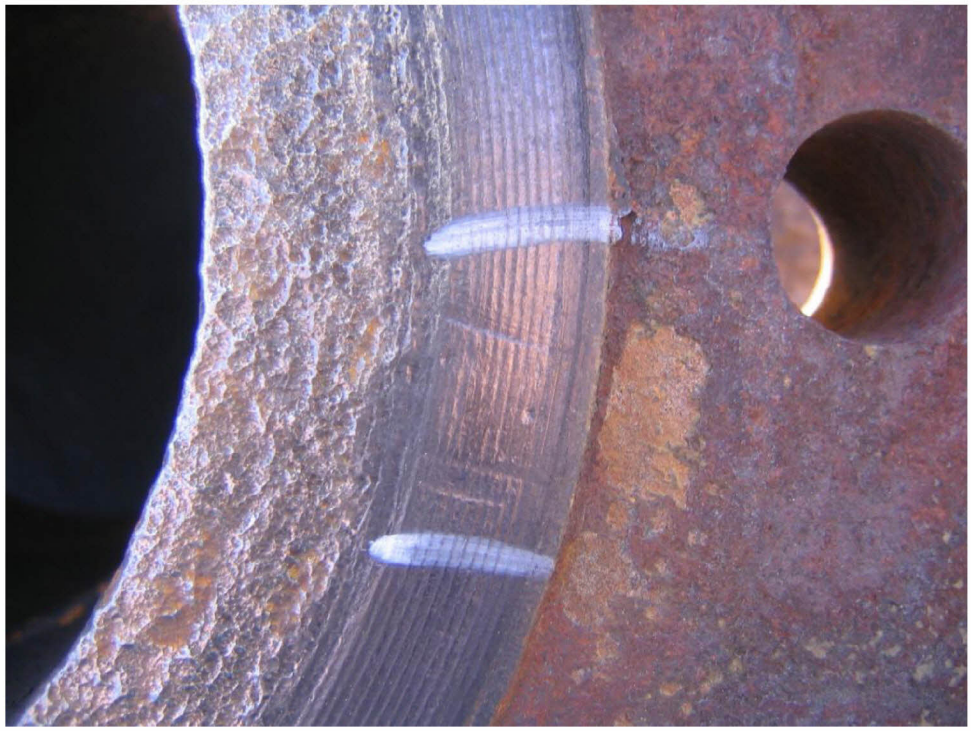

Figure 4.5.10.1. Gasket surface damage to channel nozzle flange.

Ref S/D EWO# BE416-E1 Rev. 0

4.4.11 E-1110 A/B

E-1110 A/B were opened, pulled, and inspected. Significant corrosion was discovered on the exterior of the E-1110B bundle. The corrosion was significant enough to require a complete retube.

E-1110 B bundle was retubed in-kind with SA-214 C.S. tubes. The past data indicated that a C.S. bundle should last until the next turnaround. After reviewing the processes, we noticed that the shell side temperature was 520F – 570F. Given this data, and the relatively short life (7 years) of the bundle, a change in metallurgy may be warranted. We did not have enough time to perform this study, but it should be looked at before next S/D.

The E-1110A bundle did not have any significant corrosion. The process enters B first at ~570F and leaves A at ~520F. Research is needed to determine why one bundle saw significant corrosion and the other saw almost none. Both bundles were replaced in the 98' shutdown.

Repaired a stiffener bar and the partition plate on the channel for E-1110 B. The partition plate was bent back into shape and the bar was re-welded to the plate.

During installation, the contractor damaged the gasket surface on the channel nozzle of E-1110B. We placed the gasket on the surface of nozzle and took extensive measurements. The damage only crossed ~43% of the gasket surface, so no repair was performed.

The shell pot was ordered, but not replaced on E-1110B. Benicia Fab agreed to store the pot at their facility, and it should be there if it is ever needed.

Figure 4.5.11.1. Gasket surface damage to channel nozzle on E-1110B.

Ref S/D EWO# BE418-E1 Rev. 0
Ref S/D EWO# BE418-E2 Rev. 0
Ref S/D EWO# BE418-E2 Rev. 1
Ref S/D EWO# BE412-E3 Rev. 0

RECOMMENDATION: Look into a metallurgy upgrade for E-1110B and possibly one for E-1110A. Many tubes in B had 90% wall loss after only 7 years.

4.4.12 E-1111

Bundle was removed, cleaned, and inspected. No problems were reported by inspections for the channel, shell, or channel cover. We repaired one gouge in the back of the fixed tubesheet that was caused by

contractor error. The spot was machined off by Benicia Fab. The bundle tubes were in good shape.

Figure 4.5.12.1. Photo of the damages to the tubesheet on E-1111.

Ref S/D EWO# BE419-E1 Rev. 0

4.4.13 E-1112

Bundle was removed, cleaned, and inspected. No problems were noted for the bundle, channel, shell, or channel cover. The bundle might need to be retubed next turnaround due to 4.3 year estimate to ½ wall. Three tubes were plugged.

RECOMMENDATION: Determine whether or not retube is necessary next turnaround. Estimated time to half life is 4.3 years according to inspections.

4.4.14 E-1113

Bundle was removed, cleaned, and inspected. No problems were noted for the bundle, channel, shell, or channel cover.

4.4.15 E-1114

Bundle was removed, cleaned, and inspected. Inspections issued a TAW to repair the channel nozzle flange surface. This was denied because both the channel flange surface and the mating flange in the field had no noticeable damage. The TAW was written because it appeared that process had been leaking.

The bundle had four tubes that showed 20-29% wall loss. There were no other problems to note.

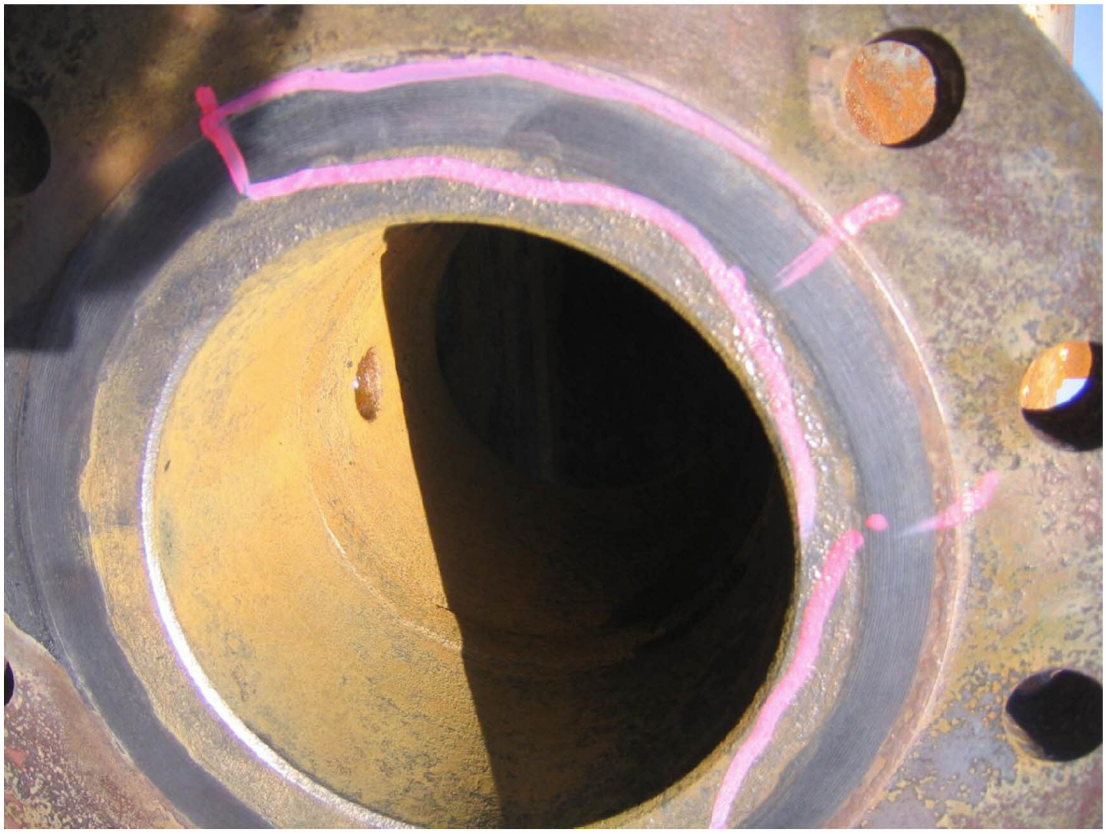

Figure 4.5.15.1. E-1114 gasket surface that was written up by inspections.

4.4.16 E-1119

This fin fan was opened, cleaned, and inspected. No wall loss was discovered.

4.4.17 E-1128

This fin fan was opened, cleaned, and inspected. No wall loss was discovered.

4.4.18 E-1148

Bundle was removed, cleaned, and inspected. No problems were noted for the bundle, channel, shell, or channel cover.

4.4.19 E-1149

This fin fan was opened, cleaned, and inspected. No wall loss was discovered.

4.4.20 E-1160 A/B

The bundles, channels, and channel covers for E-1160A/B were replaced in-kind with new parts from Graham. The bundles are admiralty brass while the channels and channel covers are carbon steel. The channels have a new anode design that is detailed in the drawings.

Figure 4.5.20.1. Layered lamiflex for E-1160A/B

The lamiflex for the exchangers was supplied in 2' single strips, rather than a continuous strip with 8 layers. We decided to install the lamiflex in layers of 4 that were overlapped to create 8 layers total. This should be replaced with one continuous strip next time the bundles are pulled.

The A shell had some delaminating occurring in the back. This was inspected and UT measurements were taken. Inspections did not recommend any repairs.

The old exchangers had some wood in the tubes, but they also had a significant amount of rocks and other debris. The supply pumps should have a suction screen installed.

Ref S/D EWO# BE449-E1 Rev. 0
Ref S/D EWO# BE449-E2 Rev. 0

RECOMMENDATION: Look into the feasibility of installing a suction screen on the pumps supplying these exchangers.

RECOMMENDATION: Install one continuous strip of admiralty brass lamiflex next time the bundles are pulled.

4.4.21 E-1161

This exchanger was pulled and cleaned. The channel and channel cover were replaced in-kind with carbon steel. The titanium bundle was not replaced and the inspection showed no wall loss. Two tubes were plugged because of mechanical damage.

The floating head cover showed significant undercut corrosion near the flange. This area had been previously repaired in 1988 with a Monel overlay. We ground out the corrosion and weld built with the same Monel weld procedure. Because the flange was thick, the weld overlay only replaced material that had been machined deeper than 3/8". It might be prudent to order a new floating head for next shutdown.

The lamiflex for this exchanger was replaced with Inconel 625 because we did not have enough lead time to replace it with titanium. This was acceptable per metallurgist. The titanium lamiflex that came out was extremely brittle. There is one 19' x 3.5" piece of lamiflex with six strips (non-tapered).

Extensive cracking was noted on the bundle because of titanium embrittlement. There were cracks on the impingement plate welds and the chassis welds. There was a TAW written to cover this, but the damage was not extensive enough to warrant any repair. The bundle is bolted together, so we were unsure why it was also welded.

Figure 4.5.21.1. Undercut corrosion on E-1161.

Figure 4.5.21.2. Machining and weld repair on E-1161 floating head.

This exchanger has a backup ring for the floating head. This ring acts a load spreader. The contractor almost installed the exchanger without the ring.

Ref S/D EWO# BE451-E1 Rev. 0
Ref S/D EWO# BE451-E2 Rev. 0

RECOMMENDATION: Due to titanium embrittlement, it might be better to clean these bundles in place. This should help prevent further cracking.

RECOMMENDATION: Determine whether cracking should drive us to replace the bundle next turnaround.

RECOMMENDATION: Replace the floating head or develop a long term replacement plan.

4.4.22 E-1162

This exchanger was pulled and cleaned. The channel and channel cover were replaced in-kind with carbon steel. The titanium bundle was not replaced and inspection showed no wall loss.

The floating head cover showed significant undercut corrosion near the flange. This area had been previously repaired in 1988 with a Monel overlay. We ground out the corrosion and weld built with the same Monel weld procedure. Because the flange was thick, the weld overlay only replaced material that had been machined deeper than 3/16". It might be prudent to order a new floating head for next shutdown.

During the turn around it was discovered that the lamiflex for this exchanger was Titanium. Lamiflex was replaced with Inconel 625, due to long lead time to replace it with titanium. This was acceptable per metallurgist. The titanium lamiflex that came out was extremely brittle. There is one 17' x 3.5" piece of lamiflex with six strips (non-tapered).

During the hydrotest, tube leaks were found when pressuring up the shell side of the exchanger. The tube side hydro passed with no problems. Because the shell side operates under vacuum, it was determined to approve the hydro (Process and Designs) because the tubeside hydro is more representative of the actual operation.

6" studs were used instead of 8.5" on the floating head because they were plenty long enough. It was discovered that the 8.5" studs were the correct length except the back up ring was missing. When the bundle was pulled there was not back up ring, therefore it must have not been re-installed during a previous shutdown. The exchanger was reassembled as found with no backup ring.

Ref S/D EWO# BE452-E1 Rev. 0
Ref S/D EWO# BE452-E2 Rev. 0

RECOMMENDATION:

- Evaluate the need for a new bundle based on tube roll leaks.
- Evaluate Inconel 625 vs. Titanium Lamiflex. May want to order one of each prior to S/D. If Inconel is gone or severely damaged use Titanium.
- Replace the floating head or develop a long term replacement plan. If there is a possibility of a bundle replacement consider possibility of a U-tube bundle.

4.4.23 E-1163 A/B

These bundles were pulled, cleaned, and inspected. Inspections reported nominal wall loss for the A bundle. There were no problems with the shells, channels, or dollar plates.

4.4.24 E-1164 A/C

These fin fans was opened, cleaned, and inspected. No wall loss was discovered.

4.4.25 E-1165 A/B

These bundles were pulled and inspected. The bundles showed no wall loss.

The channels on both bundles required repairs because the baffles had become bent from the high DP. These were cut out and replaced. The repair was not code, because the baffle is not pressure containing.

The channel cover on the B bundle was skim cut because of mechanical damage. A channel nozzle bleeder valve was replaced in-kind on the A bundle.

Ref S/D EWO# BE461-E1 Rev. 0
Ref S/D EWO# BE462-E1 Rev. 0
Ref S/D EWO# BE462-E2 Rev. 0

4.4.26 E-1168

This fin fan was opened and inspected. No wall loss was discovered.

4.4.27 E-1178

Bundle was removed, cleaned, and inspected. No problems were reported by inspections for the channel and channel cover. The bundle showed no wall loss.

A TAW was written for a thin nozzle on the shell of E-1178. The short term corrosion rate put T-min at 5 years, so we (inspections, design) decided to replace it next turnaround and to monitor it on the run. If necessary, it could be replaced in a pitstop.

4.4.28 E-1185 A/B

Both of these exchangers were opened, pulled out about 10", regasketed, and reinstalled. The shell pot, channel, and the channel cover gaskets were replaced as well.

4.4.29 E-1188

This exchanger was retubed in-kind due to extensive corrosion. There were no other repairs performed.

Ref S/D EWO# BE485-E1 Rev. 0

4.4.30 E-1197 A/B

Both bundles were replaced in-kind by Benicia Fab. The shells were pulled and sent to BFM, where the bundles were installed and hydrotested. The entire unit was shipped back and installed.

Ref Drop Folder in D&R Library